United States
Department of
Agriculture

Forest Service

**Intermountain
Research Station
Ogden, UT 84401**

General Technical
Report INT-183

May 1985

Below-Cost Timber Sales: Analysis of a Forest Policy Issue

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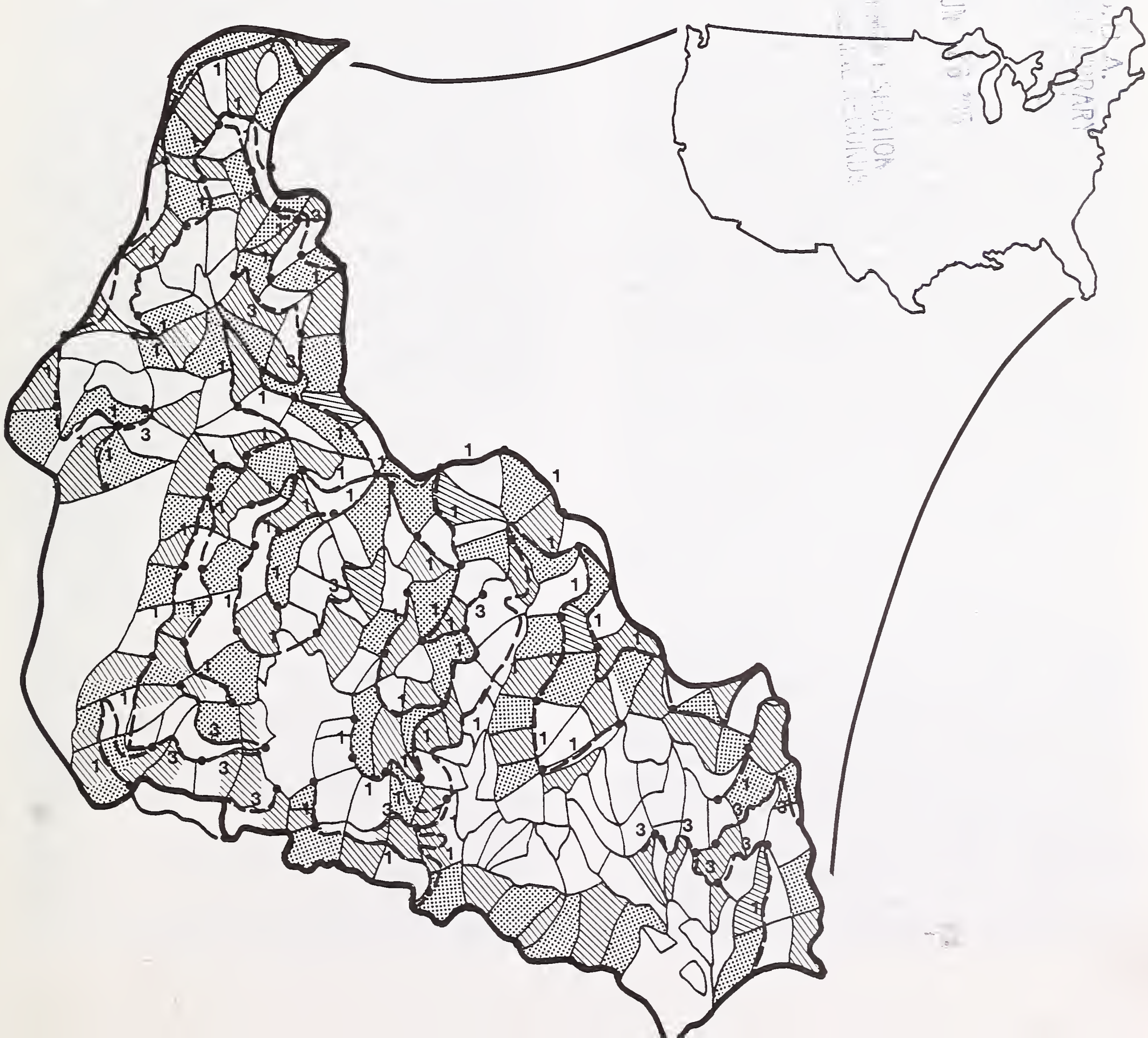

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RESEARCH SUMMARY

A series of major reports have recently raised this question: Should the USDA Forest Service participate in timber sales where the revenues generated are below the costs of selling the timber? While differences exist regarding which costs and what benefits should be included in analyses, there appears to be general agreement that below-cost sales are, by and large, undesirable and inappropriate. The authors believe that the desirability of a below-cost sale depends on and cannot be evaluated apart from the managerial context within which the Forest Service operates. That context is spelled out in the policy and procedures associated with the National Forest Management Act of 1976, which calls for integrated land management.

Timber sales, whether below cost or not, must be assessed in terms of how they fit into a comprehensive program of management for a National Forest. The methods used to assess below-cost sales in this study were derived from a study designed to improve the analytical procedures for coordinating timber and transportation management within integrated land management. A series of computer-based optimization models were developed for two study areas. The computer models identified the mathematically optimal pattern (location and timing) of both timber harvest and road construction so as to maximize Forest Service discounted net revenue, subject to constraints imposed to portray the area-wide multiple-use objectives and direction of management, as specified in the applicable forest plan. Net revenue is quite analogous to "profit"—the difference between receipts and expenditures. Discounting simply adjusts net revenues for the fact that they occur at different points in time.

Managerial goals can greatly affect the presence and amount of below-cost sales. On the study areas, as the optimal pattern of roads and timber harvests was subjected to increasing restrictions, discounted net revenue dropped markedly, by as much as 70 percent. Although all discounted net revenues on both study areas remained positive, the likelihood of below-cost sales increased as discounted net revenues decreased. Positive discounted net revenues do not mean that below-cost sales have been avoided. They merely mean that overall financial viability is favorable. In fact, a net loss might not be undesirable if that were the most cost-effective way of accomplishing area management required by the forest plan. Further analyses of the positive discounted net revenues identified negative cash flows (where costs exceeded revenues) either for entire time periods or for specific timber sales. In these analyses, below-cost timber sales were compatible with maximum and positive discounted net revenue. Attempts to eliminate negative cash flows were only partially successful and then only with an attendant reduction in discounted net revenue, a loss in efficiency.

Analytical perspective also affected below-cost analyses. If a perspective of multiple time periods and sites is adopted, the capital investment nature of a transportation network can be correctly analyzed. Otherwise the entire cost of permanent roads will appear to be apportioned to the first sale in an area, thereby inappropriately exaggerating the costs associated with that sale. Including benefits other than timber receipts can also clearly affect analyses and change the interpretation of below-cost sales. Although these benefits are difficult to quantify in net revenues, they are present, reflected in objectives and concerns that form the basis for area management. Analyses show that if 25 Percent Fund payments (monies paid to counties) are treated as a cost, discounted net revenues on study areas can be reduced by as much as 75 percent and can change from positive to negative. Analyses also show that treating these payments as costs can change otherwise positive cash flows for a given time period to negative cash flows, thereby portraying the sale as below cost.

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INTRODUCTION

During the spring of 1984, the GAO (General Accounting Office) (1984), the CRS (Congressional Research Service) (1984), and others issued reports that could have a profound and lasting effect on policies and procedures of the USDA Forest Service and management activities within the National Forest System. The central theme of the GAO and CRS reports seems to be that the Forest Service has a problem—there have been instances where receipts from some timber sales are less than what it costs to develop, implement, and administer those sales. This concern has become known as the Below-Cost Timber Sale (BCTS) issue. Concern over BCTS is quite understandable, particularly in light of national concern over Federal budget deficits, balance-of-payments deficits, and so on. Any time anyone or any organization is apparently losing money, there would seem to be a problem.

The GAO and CRS reports have prompted wide-ranging controversy, debate, analyses, and responses. Forest Service critics (see, for example, Sample 1984 and Stout 1985) have interwoven the BCTS issue with those of roadless areas, deficit timber sales, possible industry subsidies, and more. Forest Service supporters (see, for example, LaSalle and others 1984 and Rasmussen 1985) have criticized the GAO and CRS report data bases and their extrapolation, argued procedural points, documented specific cost-cutting efforts, developed procedures for apportioning joint costs, and so forth.

Criticism over timber sale costs and revenues is hardly new (see, for example, Barlow 1979). Some critics have long argued that timber receipts should cover not only all sale-related costs (see, for example, Hyde 1981) but also other accumulated costs. In fact, past controversies, such as the Bitterroot controversy and its "timber-mining" issue (Behan 1971), were frequently rooted in the quest for the proper way to think about and analyze the economics of timber management on National Forests. The quest may be unending, if for no other reason than that the managerial context within which the National Forest System operates is constantly changing. The way the organization does business depends on that context. There is no fixed method of operation or standard of performance. An agency's procedures and performance must be judged on the basis of the existing managerial context.

The Forest Service's current managerial context is based on a complex of administrative, statutory, and case law, especially as related to the Multiple Use Sustained Yield Act of 1960, the National Environmental Policy Act of 1969, the Forest and Rangeland Renewable Resources Planning Act of 1974, and the National Forest Management Act of 1976 (NFMA). Legal mandates clearly call for the Forest Service to undertake land management planning, programs, and practices for National Forests that are sustainable in the long run, produce an integrative mixture of goods and services, are responsive to social and environmental influences, and give rise to maximum net public benefits. The language, logic, and mathematics of land management planning suggest the hypothesis that optimal forest management can be efficiently accomplished in the presence of below-cost sales. That is, efficiency and BCTS can coexist and are not necessarily incompatible.

This report is based on the premise that an assessment of below-cost timber sales requires much more than a simple, straightforward comparison of the immediate revenues and costs for specific sales. It demands a rigorous examination of the role played by specific timber sales and groups of sales in the context of integrated land management, over time and space. A series of analyses illustrating actual management options for timber harvest and road construction activities in the context of an integrated land management plan are presented. The illustrations test the hypothesis that optimal land management and BCTS can coexist. We begin first by briefly discussing the perspectives and procedures used in this study. We then discuss the effects of the managerial context and analytical perspective on BCTS conclusions. The report ends with our conclusions on the issue of below-cost timber sales.

PERSPECTIVE AND PROCEDURES

This report is directed toward the prospect of future occurrence of below-cost timber sales. The data and conclusions presented by the GAO or CRS reports will not be directly analyzed because those data were derived from time periods when the managerial context was quite different from today's. Because several years of "lead time" are required for a timber sale, most, if not all, of the timber sales forming the GAO and CRS report data bases were prior to integrated land management planning currently required by NFMA. The initial round of forest planning is only now being completed, and timber sales pursuant to these plans are only now being implemented. Some of the earlier sales used in the

reports were necessarily even pre-NEPA (National Environmental Policy Act). We make no judgment as to whether previous below-cost sales were appropriate or inappropriate. Nevertheless, below-cost sales may recur, but now as a product of the current managerial context, including the policies and procedures surrounding NFMA.

The Policy and Management Context

Pursuant to current policy, especially the NFMA of 1976 and its implementing regulations, integrated land management planning is accomplished for each National Forest. The forest plan chosen is expected to yield maximum "net public benefits," not necessarily the largest revenue. After completion, forest plans will be implemented and the accomplishments and effects monitored. Because forest plans typically deal with broad average values applicable to wide geographical areas, they often lack specificity, especially spatial specificity, needed for direct implementation at the project level. Nevertheless, standards and rules for managing areas contained in the forest plan amount to the side boards within which local management activities take place. Integrating timber harvest activities with a transportation network is an important phase of implementation. These activities are at the heart of the BCTS issue.

Integrated land management planning clearly requires a systematic approach. Many possible land use prescriptions are allocated to many different land strata so as to best achieve a set of multiple goals, under many legal and resource constraints. The system as a whole is more than the simple linear sum of its parts. Management planned for any specific parcel of land within the system may not be optimal if that parcel were a separate entity of its own. This is, however, the type of management that results in optimal management of the Forest as a whole.

A simple example should clarify this point. Assume a landowner has two parcels of forest land which are to be harvested over two decades so as to maximize net revenue. Assume further that harvesting one parcel per decade is desired in order to provide an acceptable cash flow. The expected net revenues for harvesting timber on the two parcels are as follows:

Parcel 1	Harvest in decade 1:	$100,000
	Harvest in decade 2:	90,000
Parcel 2	Harvest in decade 1:	$105,000
	Harvest in decade 2:	80,000

Given these net revenues and the landowner's objectives, the best plan would be to harvest parcel 2 in decade 1 and parcel 1 in decade 2, even though this approach does not yield the largest possible returns from parcel 1.

Because, within the Forest Service, management of subsystems (functional or geographical) takes place within the framework of the larger system (the Forest), analysis of the BCTS issue cannot focus on individual sales. Rather, the BCTS issue must be discussed within the context of long-term management for the geographic area where the sale resides, and within the context of overall management for the Forest as developed through the land management planning process.

Link to Existing Research

The analytical procedures used in this report were derived from a research study conducted by Jones (1983) entitled "An Empirical Evaluation of the Integrated Resource Planning Model for Use in Area Transportation Planning" (referred to hereafter as the Jones study). The motivation behind that study was the need to implement forest plans, to provide an analytical link between integrated land management planning and site-specific, project-level planning and management. Three features of the Jones study, as they affect BCTS analyses, warrant special mention.

First, the Jones study used analytical techniques well suited to the BCTS issue—in particular, the IRPM (Integrated Resource Planning Model) (Kirby and others 1981). IRPM is a mathematical modeling system falling in the general class of analysis known as linear programming. In our application, IRPM was formulated to simultaneously analyze timber harvest and road construction alternatives on both a time- and site-specific basis. Constraints can also be imposed on a time- and site-specific basis to represent the directions or requirements provided to site-level activities by the forest plan. IRPM was used in below-cost sale analyses to identify the schedule of timber harvest and road activities that appears to be most efficient, within the direction set forth by the forest plan. For the purpose of assessing the BCTS issue, the IRPM modeling approach has an enormous advantage: subject to the constraints imposed, it would be very difficult—nearly impossible—to improve on an IRPM-based solution. It is essentially the best possible.[1]

Second, any effort dealing with the question of long-range planning must ultimately specify a planning horizon (how far in the future) and the intervals of time (annual, decadal). The Jones study adopted a 50-year planning horizon with the following intervals:

Time period 1— 0 to 10 years (first decade)

Time period 2—11 to 20 years (second decade)

Time period 3—21 to 50 years (third to fifth decades).

Analyses in this report are based on the same time horizon and intervals.

Third, the Jones study employed an experimental design that replicated procedures on two study areas in Montana. The two areas provide actual, real-world examples of National Forest System personnel planning for the implementation of a forest plan. The forest planning process had designated each of these areas for timber production and set forth standards and management direction. The areas were selected for use in the Jones study because their management had been identified as high priority for implementation of forest plans and

[1]IRPM is termed a mixed-integer programming (MIP) formulation, in that some of the variables must take on values of 0 and 1 for a solution to be meaningful. At this time, there are no algorithms available to strictly optimize a large MIP formulation, such as those developed by IRPM, at a reasonable cost. Our study used a technique which provides approximately optimal solutions to MIP problems.

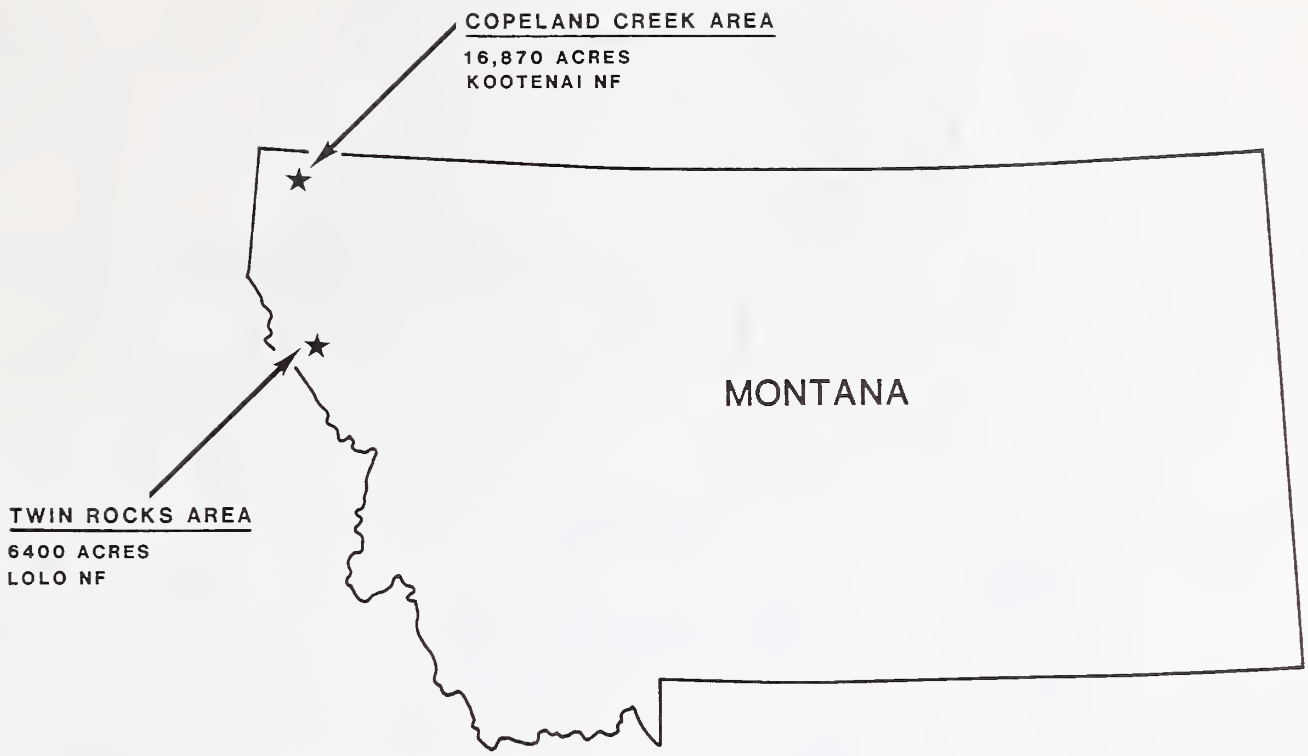


Figure 1.—Location of study areas in western Montana.

because of the willingness of National Forest System personnel to support and assist in the research. As such, they provide acceptable study areas for research into alternative implementation approaches and methods.

Figure 1 shows the locations of the two study areas in western Montana. The Twin Rocks area is located on the Lolo National Forest about 9 miles south of Thompson Falls, MT. It occupies about 6,400 acres (10 mi^2) of the 2.1-million-acre Lolo National Forest. The Copeland Creek area occupies about 16,870 acres (about 26 mi^2) of the 2.2-million-acre Kootenai National Forest. It is located about 18 miles north of Libby, MT.

The study areas are typical of the mountainous terrain found throughout most of western Montana. They are each large enough to encompass a range of elevational, slope, and aspect differences. Timber on the areas is typical of the general forest zone; definitely not the best timber management opportunities, but far from the worst. Neither of the areas is totally isolated, each being already partially roaded. Approximately 10 percent of the Twin Rocks area and 40 percent of the Copeland Creek area are accessible by existing roads.

Information and Data Used

The information and data used to assess the BCTS issue are the same as those needed to accomplish site-specific area planning—cutting unit delineations; timber management projects; road projects; timber, water, and sediment yields; and economic information. Information and data were jointly developed between researchers and National Forest System personnel. Whenever professional, managerial judgments were required (such as location of roads), those judgments were made by National Forest System personnel. The information and data used were real or as realistic as possible.

Cutting Unit Delineations.—The land within each area was delineated into potential timber harvest or cutting units by National Forest System personnel. All acres within a unit were enclosed within a single boundary. The criteria used for delineation were that the cutting units be consistent with the type of management identified for the area and that logging was feasible. These units served as the building blocks for potential timber sales. That is, a sale consists of multiple cutting units. Figure 2 illustrates the result of delineations, showing the 221 cutting units identified for the Twin Rocks area. The Copeland Creek area was delineated into 282 units. Units varied in size, with the largest being about 40 acres.

Timber Management Projects.—Timber management projects were developed for each potential cutting unit. These projects identified the packages of land management and timber harvest activities from which the optimization procedure can choose. Each project included all the activities that occur, from sale preparation to regeneration of the site. Composition of the projects followed the type of management to be applied as identified in forest planning. Therefore, the projects for a given unit varied primarily by the time period in which the list of activities would be applied. Choice of silvicultural system was also an option for about a third of the cutting units, whenever more than one approach to cutting unit management was possible and yet consistent with the forest plan.

Road Projects.—Road construction projects were both coordinated with a network of potential roads and were designed to be compatible with the logging methods selected for the units in the area. The transportation network was delineated into a series of road segments, or links, separated by nodes. The network developed for the

Figure 2.—Cutting unit boundaries for Twin Rocks area.

Twin Rocks area is shown in figure 3. Road construction alternatives developed for each link varied by time period in which construction would occur and, for some links, by road standard. Road project alternatives are linked to each other and to the timber harvest projects by constraints that ensure access for the time period and road standard required. A network of links represents an "over-kill" in that more links are included than those actually needed to access the units in an area. This provides alternative access routes to cutting units and groups of units. Some of the potential links would not be chosen for construction in any one management alternative for an area.

Yield Information.—Three types of physical yield information were used—timber, water, and sediment. Timber yields for each cutting unit were projected for each time period. Because the timber management projects identify activities in a site-specific manner, yield projections were based on the most specific timber data available. Timber volumes were projected to the midpoints of the time periods used in the analysis. This was required to give proper weight to the likelihood of choosing to harvest in a later rather than an earlier time period. Water yields were tied to type and timing of timber harvest activities. Sediment yields were tied to type and timing of road project activities and harvest activities. The relationships for projecting water and sediment yields were provided by forest hydrologists on the cooperating National Forests.

Economic Information.—Timber was valued as mill-delivered logs. Several tree-species and log-size categories were used to handle variations in per-unit value. Costs included all purchaser costs of harvesting and getting the logs to a mill and all Forest Service costs for preparing and administering timber sales, specified roads, brush disposal, and regeneration of timber. Forest Service costs that did not vary (Forest Service Regional Office and Washington Office overhead costs) were not

Figure 3.—Potential transportation network for Twin Rocks area.

included. All economic information, including the base prices and costs, assumptions about real changes in prices and costs, and the discount rate, was developed in consultation with economists in the cooperating National Forests and in the Regional Office of the Northern Region. Prices, costs, and the 4-percent discount rate used were expressed in terms of constant (real) 1982 dollars.

The BCTS analyses used two economic criteria—discounted net revenue (DNR) and net sale value—each serving a somewhat different purpose. DNR is a measure of the net effect area management has on the overall financial receipts experienced by the Forest Service at the Forest level. The DNR concept can be divided into two parts: D and NR. The D part simply refers to the standard concept of discounting. Whenever a cost or revenue occurred in the future, it was discounted to the present. The NR (net revenue) portion of DNR has the following components:

Start: \$ Log value (mill-delivered)
(+) Bid premium (estimated)
(−) Haul costs
(−) Purchaser slash disposal costs
(−) Logging costs
(−) Profit and risk margin

=\$ Stumpage price (≅ "high bid")
(−) Road costs or purchase road credits
(−) Site improvement (K-V) and brush disposal

=\$ Received for timber
(−) Sale preparation cost (including specialists)
(−) Sale administration cost
(−) Silvicultural examination cost

End: =\$ Net revenue for Forest Service

Subtracting road costs, as shown above, illustrates that mode of financing (appropriated monies or timber purchaser road credits) does not affect net revenue.

The second economic criterion used was net sale value (NSV). NSV is simply an undiscounted version of DNR. NSV is used to portray the undiscounted net cash flow by time period. NSV reflects the concept of a BCTS as discussed in the GAO and CRS reports. In those reports, a BCTS was one with a negative cash flow, where the receipt dollars were less than the expenditure dollars. Here, a BCTS is depicted by and synonymous with a negative NSV.

The concept of BCTS has widespread intuitive meaning, conjuring the notion of financial loss—a net flow of dollars away from the Forest Service. But agreement as to how to identify a BCTS is anything but widespread. Should overhead costs be prorated and charged to a specific sale? What is the best way of apportioning the joint costs of roads? Should 25 Percent Fund payments to counties be treated as a timber sale cost? The possibilities are many. These questions are critically important to a BCTS analysis when the approach is that of analyzing isolated, individual sales. But the isolated, individual sale approach is not the perspective of our analyses. We view an individual sale as merely part of a program to implement a forest plan. While adoption of this perspective does not relieve us of our obligation to correctly portray costs, it does lessen the analytical importance of cost specification and several cost-related questions. In fact, some questions, such as apportioning road costs, are irrelevant to our analytical perspective. Costs included in our analyses are intended to portray those timber sale and road costs relevant to efficient forest plan implementation.

A brief explanation for valuing timber as delivered logs and including purchaser costs (rather than using stumpage prices) is in order. Forest Service design of road networks and timber sales can affect purchaser costs, which in turn are counted against the price of stumpage. Road network design obviously affects haul costs and road construction costs. Timber sale design affects stump-to-truck costs, purchaser slash disposal costs, and other costs associated with specifications in timber sale contracts. Any cost the Forest Service imposes on a purchaser can be expected, on the average, to be subtracted from the amount the Forest Service receives for the timber sold. Thus purchaser costs can be expected to have the same effect on DNR for the Forest Service as costs incurred directly by the Forest Service. As an alternative to mill-delivered log value, predicted stumpage price could be used directly as the value of Forest Service timber. The problem with this approach is that transportation costs must be estimated in stumpage price calculations. Yet these costs are not known for a given cutting unit until after the model is solved—such costs depend on the resulting road network. To estimate these costs a priori would defeat some of the advantage expected of IRPM.

Models Built

IRPM models were built for each study area. The purpose of these models was to maximize an objective function—in this case DNR—subject to a set of constraints.

The variables in IRPM fell into one of three categories: (1) harvesting alternatives developed for the potential cutting units, (2) road construction alternatives developed for the links in the road network, and (3) traffic variables that measure the volume of traffic by time period for each link.

Constraints fell into two categories. The first category was the constraints that are required for the model to operate properly. These include: (1) constraints that limit to one the number of resource projects that can be simultaneously allocated on a cutting unit, (2) constraints on road project variables that ensure access for resource projects, (3) constraints that "connect" the traffic variables so they correctly measure the volume of traffic flowing over the road segments, and (4) various other constraints of similar nature. For the most part, these constraints are developed by IRPM software and will not be discussed further here.

The second category of constraints was user-specified. These constraints were used to depict the style or direction of management to occur on an area. First, there were upper- and lower-limit constraints on timber to be harvested by time period. These were based on the disaggregated forest plan and identify the quantity of timber that the plan indicates should be harvested in the area during each of the time periods. Second, there were upper-limit constraints on the number and spatial distribution of acres on which harvests are allowed by time period. The purpose of these constraints was to maintain adequate dispersion of harvesting activities for watershed, visual, recreation, and wildlife purposes. We term these "adjacency" constraints. Third, there were constraints dealing with environmental effects of special interest. For example, sediment or water yield constraints were included to limit sediment or water production by time period for each watershed of interest.

Each IRPM model was intended to do one thing: identify the mathematically optimal pattern of cutting units and transportation network such that the level of discounted net revenue was as large as possible, subject to the management objectives and concerns specified. The optimal pattern of cutting units means not only identifying which units would be harvested, but when each unit would be harvested. The optimal transportation network refers not only to which road segments would be constructed, but when the construction would take place and to what standard, if appropriate.

A solution to these IRPM models provides a number of items of information. First, it calculates the highest DNR that can be achieved, given the constraints imposed. Second, it calculates NSV, costs broken down a number of ways, harvest volume by species groups, and water and sediment yields by drainage, all by time period. Third, it identifies those harvesting alternatives and road construction alternatives that maximize DNR.

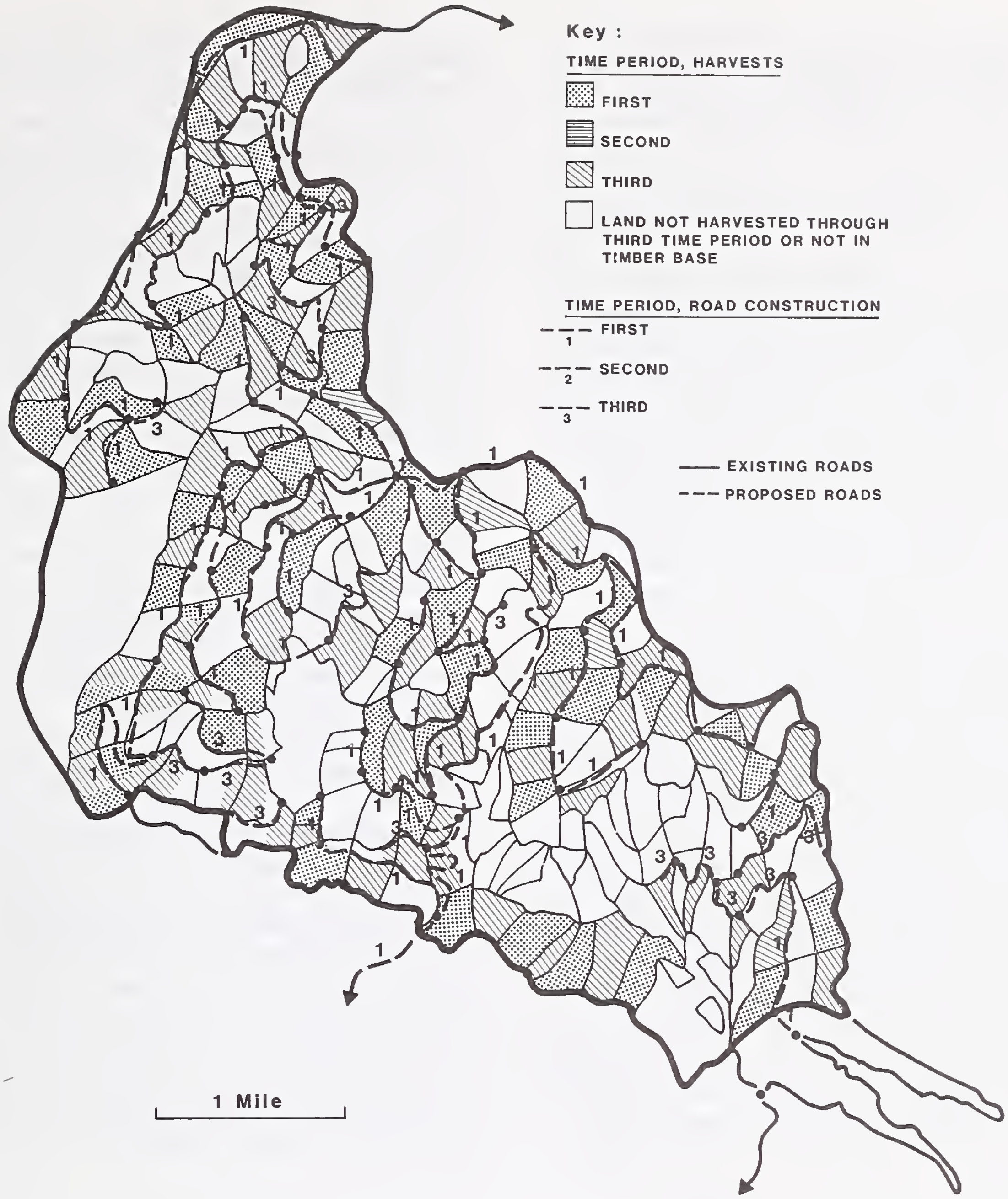


Figure 4.—Twin Rocks area solution: maximum DNR with adjacency and lower limit timber harvest constraints.

A solution for the Twin Rocks area is illustrated in figure 4. In this solution, the total timber harvest in time period 1 was required to be at least 14.0 million bd ft and adjacent units could not be harvested within 20 years of each other. In this case all timber harvest and road construction activities occur in time periods 1 and 3, as shown by the different shading patterns on the cutting units. Not all cutting units are harvested during these time periods. Similarly, only a portion of the potential road network (as shown previously in fig. 3) will be constructed during the time periods analyzed. The DNR for this solution is $392,000, meaning that discounted difference between Forest Service total costs and timber receipts is almost $400,000. This level of DNR and the associated pattern of cutting units harvested and road segments constructed has this significance: given the data used in the model, it would be nearly impossible to identify another pattern of cutting unit and road segment selection and timing that could achieve a higher level of DNR and yet satisfy the constraints.

EFFECT OF THE MANAGERIAL CONTEXT ON BCTS CONCLUSIONS

A central theme of this paper is that the BCTS issue should be assessed within the managerial context relevant to the Forest Service, amounting to an integrated systems approach to management. The role played by an individual subsystem, such as a study area, is determined by its linkage to other subsystems and to management of the overall Forest system. These are multidimensional linkages involving products, time, and space. Individual management actions, such as a timber sale, relate not only to themselves but to other individual actions in the management of a subforest

geographical area. The following section assesses the BCTS issue, first, from the standpoint of the link between area management and forest management; second, from the standpoint of the link between timber sales and area management.

Management Objectives and Discounted Net Revenues

In multiple-use forest management, some objectives and concerns are relatively easy to express in dollars; others are not. When optimization models are used at either the Forest or area levels, management objectives and concerns can be reflected in the choice of activities available within the model, a model's objective function, or as constraints on the optimization process. Dollar-expressed objectives and concerns are reflected in all three ways. The remaining management objectives and concerns are usually reflected only as activity choices or in the form of constraints, restricting the choices the optimization model is allowed to make.

Among other things, planning identifies the types of management practices to be applied to various classes or strata of land. These were referred to earlier as timber management projects or prescriptions. Timber management prescriptions vary in cost per unit timber output, with those emphasizing timber exclusively generally being the least expensive and those emphasizing both timber and nontimber outputs being most expensive. Recent research (Benson 1984) indicates that the net negative effect on Forest Service stumpage receipts for nontimber goals averages about $37 per thousand board feet harvested (range: $18 to $60). Prescriptions used in the harvesting alternatives for the IRPM models were chosen in the forest planning process. Because the same prescriptions were used for each solution pertaining to a given study area, the effect that type of prescription (those with more emphasis on timber or nontimber outputs) has on BCTS analysis results cannot be detected. The effect is present, but simply cannot be measured in our analyses.

Four sets of management objectives and concerns were identified for the Twin Rocks and Copeland Creek study areas. The optimization model's objective of maximizing discounted net revenue was common to all sets. The concerns and objectives not easily expressed in dollars were reflected as four series of constraints, as summarized in table 1. Constraints are ordered from generally least constraining to generally most constraining. A separate solution was developed for each set of constraints for the two study areas. When solved, each solution depicted the mathematically optimal pattern of timber harvest and road construction such that DNR was at a maximum and the nondollar objectives and concerns were not violated.

The Series I solutions were required to meet only adjacency constraints, wherein if a unit is to be harvested, no unit adjacent to this unit can be harvested for at least two decades. The adjacency constraints' purpose is to limit the size of harvest openings to 40 acres; 20 years following a harvest, the area is no longer considered an opening. These restrictions are typically imposed to protect wildlife and visual quality.

In Series II solutions, soil and water constraints were added to the adjacency constraints. The purpose of these constraints was to maintain water quality and fish habitat in each of four drainages in each study area. On the Twin Rocks area, stream channel stability was a major concern. Therefore, water yield was set to not exceed an 8 percent initial annual increase in each of its four drainages. Sediment production is also a concern. But because any management alternative that satisfies these rather restrictive water yield limits would also satisfy soil movement concerns, separate constraints were not imposed on sediment production. Due to the types of

Table 1.—Listing of management objectives and concerns (constraints) used in optimization modeling for Twin Rocks and Copeland Creek areas, by series

Series	Type	Twin Rocks	Copeland Creek
I	Adjacency	No adjacent cutting units could be harvested within time period (TP) 1 and TP2, or within TP3	No adjacent cutting units could be harvested within time period (TP) 1 and TP2, or within TP3
II	Adjacency	As above	As above
	Water	Initial $\uparrow \leq$ 8%	Average annual $\uparrow \leq$ 20%
	Sediment	Not used	Average annual $\uparrow \leq$ 80%
III	Adjacency	As above	As above
	Water	As above	As above
	Sediment	Not used	As above
	Harvest volume	Million bd ft in TP1 $\geq$ 14.2	Million bd ft in TP2 $\geq$ 36.0
IV	Adjacency	As above	As above
	Water	Not used	Not used
	Sediment	Not used	Not used
	Harvest volume	Million bd ft in TP1 $\geq$ 14.0	Million bd ft in TP1 $\geq$ 11.0
	Harvest type	Lodgepole pine and spruce	Not used

soils on the Copeland Creek area, stream channel stabilization was much less of a concern. Here, average annual water yield was constrained not to exceed a 20 percent increase over current yield, and sediment was constrained to not exceed an 80 percent increase over current level.

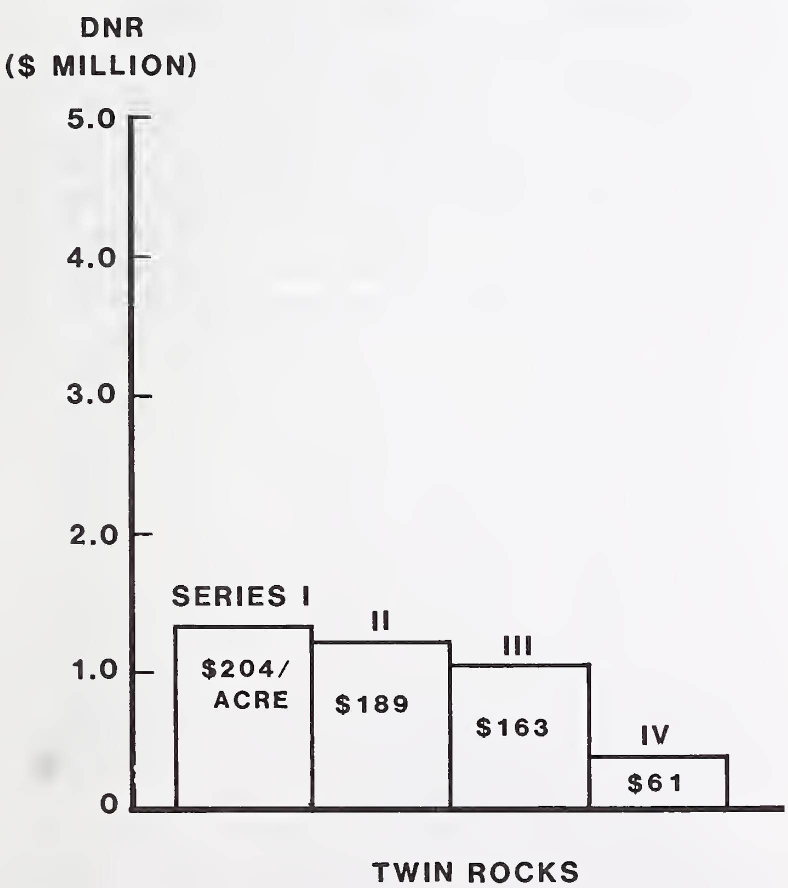
In the Series III solutions, harvest volume constraints were added to the adjacency, water, and sediment (where present) constraints. For Twin Rocks, harvest in the first time period (first decade) was to be at least 14.2 million bd ft, while for the Copeland Creek area it was to be at least 36.0 million bd ft in the second time period (second decade). Harvest volume constraints would be used to help achieve Forest-wide harvest scheduling objectives.

Series IV solutions used adjacency and harvest constraints but dropped the water and sediment constraints. On the Twin Rocks area, the general harvest volume constraint was replaced with an objective of harvesting at least 14.0 million bd ft of lodgepole pine and spruce. This could be desirable if there were stands of lodgepole highly susceptible to insects or disease. Such a harvest could help curb forest pests in addition to harvesting some of the timber type called for by Forest-wide harvest scheduling. On the Copeland Creek area, the general volume constraint was lowered to 11.0 million bd ft and moved to time period 1 (first decade). Again, this could reflect a Forest-wide harvest scheduling objective.

The values for DNR resulting from these optimization solutions are presented in figure 5. Each of these DNR values is positive, meaning that the discounted value of all receipts is more than enough to offset the discounted costs over the 50-year planning horizon. This does not mean, however, that each sale that would be developed for implementing these alternatives would necessarily have a positive cash flow, as we shall discuss later.

Twin Rocks results are consistent with typical expectations. When constraints are increased, the value of the DNR objective function decreases. The point is not that increasing constraints and decreasing DNR are undesirable. Rather, it is that with increasing constraints come decreasing DNR's and as this happens, the likelihood of BCTS increases. Timber sales associated with the Series IV solution are more likely to be below cost than Series I, II, or III. If a more restrictive Series V were created, it would be more likely to result in BCTS than Series IV. Simply stated, as DNR's drop, there is less wiggle room between costs and revenues and the likelihood of BCTS increases.

What of the Copeland Creek area? It is apparent that DNR was insensitive to the additional constraints added in Series II and III solutions. There are at least two reasons for this. Because of the more stable stream channels in the Copeland Creek area, the water and sediment constraints could be much less restrictive and still achieve the water quality and fish habitat objectives. Second, the Copeland Creek area is currently about 40 percent roaded, while only about 10 percent of the Twin Rocks area is currently accessible by roads. Thus less road had to be constructed (and less costs incurred) to achieve the harvest volume constraints imposed in the Series III solution than on the Twin Rocks area.



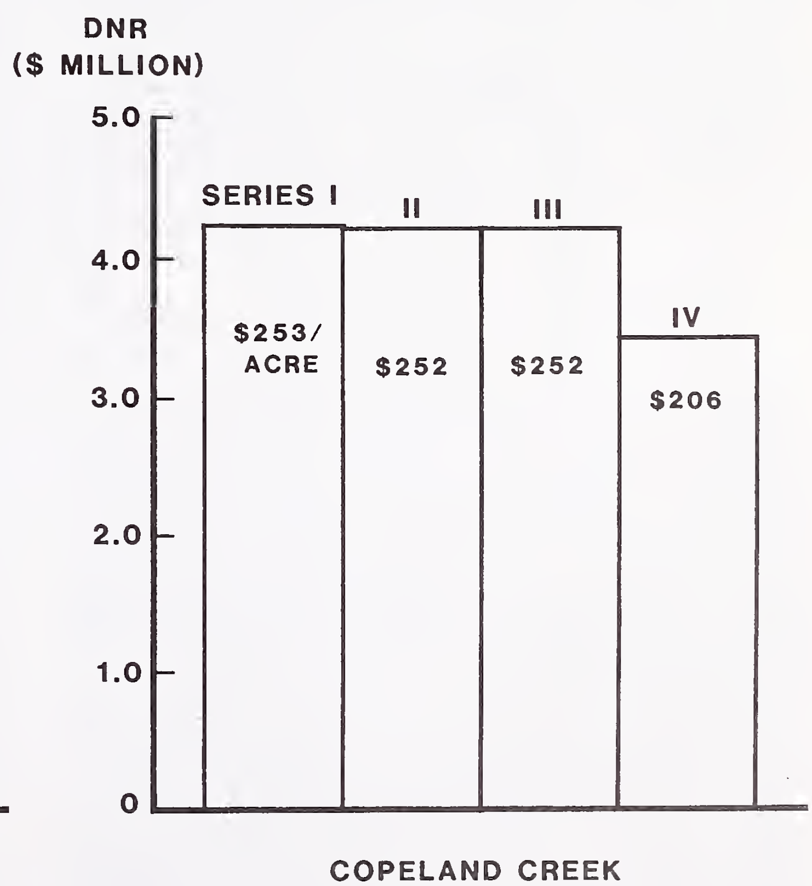


Figure 5.—Discounted net revenues associated with four solutions on Twin Rocks and Copeland Creek areas.

Most methods for calculating timber costs and revenues, including ours, will systematically work to the advantage of relatively developed areas, compared to relatively underdeveloped areas. This advantage would also extend to Forest-by-Forest and Region-by-Region comparisons. The more developed Forests would appear to have less of a BCTS "problem" than those with less development. The more developed Regions would tend to show fewer BCTS's than less developed Regions. Because roading costs are a major cost of timber harvesting, it should be no surprise that where roads are largely in place the road costs associated with future harvest will be relatively low. Where the roads have not yet been built, roading costs will be relatively high. The DNR analyses used in our study adopted the same time frame for both Twin Rocks and Copeland Creek—the present to 50 years in the future. Whereas virtually all of the Twin Rocks roading costs fit or will occur within that time frame, a substantial portion of the Copeland Creek roads had been paid for before the analysis started.

Figure 5 suggests that future development of the Copeland Creek area is a better idea than Twin Rocks. The DNR's per acre for Copeland Creek are 24 percent to 238 percent higher than for Twin Rocks. But relatively more of the Copeland Creek road costs had already been incurred and were not considered in the analysis. The influence of road costs can be illustrated by imposing an optimal road network on the data shown in figure 5. We simulated this condition by simply subtracting all roading costs from the modeling solutions. The tabulation below shows the original per-acre values and the values that would prevail if the roads were already built:

Constraint series	Original		Without road costs	
	Twin Rocks	Copeland Creek	Twin Rocks	Copeland Creek
	Dollars DNR/acre			
I	204	253	314	273
II	189	252	278	272
III	163	252	273	272
IV	61	206	218	229

If both areas already had a road network in place, per-acre net revenues for Twin Rocks generally equal or exceed those from Copeland Creek. Development of the Twin Rocks area brings higher returns than Copeland Creek, assuming roads in place. Development of Twin Rocks would be even more preferable if its roads were in place (without road costs) and Copeland Creek was at its present state of development. Financial results are heavily dependent on the state of development existing at the time of analysis.

Should the four sets of model solutions be interpreted as four management alternatives for each area? That depends on the flexibility of the management objectives and concerns stated in the forest plan. If they are restrictive, only one of the constraint series may be compatible with the forest plan. If flexible, the manager may be free to choose among all four, or possibly between pairs, such as between Series I and IV or between Series II and III. Even when all four are viable, the selected alternative need not necessarily be the one with the highest DNR. The alternative selected will be the one most compatible with securing the net public benefits implied by the forest plan. The manager would consider harvest scheduling objectives, the importance of water and sediment production, as well as current and projected conditions on the area, such as an imminent insect or disease problem. All things considered, it is possible that the Series IV solution would be judged best (essential to implementation of the forest plan), even though its DNR is substantially lower than others. In fact, if the Series IV solution is judged the best among several alternatives for area management, or is judged to be the only alternative compatible with forest plan direction, its DNR could actually be negative and yet the most efficient way of achieving Forest-wide maximum net public benefits.

Whether choice is restricted or not is a management question. We are using the four constraint series to better assess the implications of increasingly stringent management objectives and concerns on BCTS. As restrictions increase, so does the likelihood of BCTS. Similarly, lesser developed areas are more likely to encounter BCTS than those relatively more developed. If comparisons between areas, Forests, or Regions do not start from a comparable base of development, results are ambiguous and may be misleading. Results may not reflect inherent management opportunities as much as reflecting road and other development costs incurred prior to analysis.

Discounted Net Revenues and BCTS

Does a positive DNR mean that below-cost sales have been avoided? No, it certainly does not. All a positive DNR shows is that a particular management strategy makes long-term financial sense. All decision situations shown in figure 5 have positive DNR's. Yet there are or can be specific BCTS's associated with the management opportunities in both the Twin Rocks and Copeland Creek areas. The following section assesses BCTS from a decade-by-decade and a sale-by-sale point of view, both in the context of the area-wide solutions just discussed.

Decade by Decade.—Investment decisions can be, and frequently are, assessed from a variety of perspectives. Discounted net revenue, present net value, benefit-cost ratio, and internal rate of return are but a few. All are measures of overall goodness of investment. They each reduce a time-complex problem to a single criterion. Each criterion analytically handles problems of cash flow, where the typical investment incurs "up-front" costs, with revenues being received later. The analytical workhorse of these procedures is compounding and discounting with compound interest. Overall financial viability of an entire project need not be reflected by similar viability in each of the parts.

Assume that in both the Twin Rocks and Copeland Creek areas, the Series IV solutions are judged appropriate. That is, subject to adjacency constraints, at least 14.0 million bd ft of lodgepole pine or spruce must be

harvested on the Twin Rocks area during the first decade and that 11.0 million bd ft of timber must be harvested during the first decade on the Copeland Creek area. The tabulation below shows the net sale value in each area for each time period:

Time period	Net sale value	
	Twin Rocks	Copeland Creek
	Thousands of dollars	
1	−709	−819
2	—	617
3	4,121	14,983

Note that net sale value in the first time period is negative for both areas. Recall that the net sale value constitutes the net cash flow in a time period, expressed in undiscounted dollars. That means that timber sales associated with the first time period will cost more than they will return in the form of revenues: −$709,000 for Twin Rocks and −$819,000 for Copeland Creek. This is so in spite of the fact that positive DNR's ($392,000 for Twin Rocks; $3,467,000 for Copeland Creek) indicate that both management options are financially sound opportunities in the long run.

Is it unreasonable to have negative net sale values in these solutions while overall DNR is positive? Not at all. Part of the explanation for this involves the concept of the capital-investment nature of roads, which will be discussed more fully later.

Can these decade-wide BCTS's be avoided? Possibly so. But if they can, it would be only at the expense of a lower DNR. That is, elimination of below-cost sales would not increase the overall net returns to the Forest Service. In general, anything done to make these NSV's in time period 1 less negative will also reduce DNR. This is so because the decade-wide BCTS resulted when the IRPM model was programmed to find the highest overall DNR, without regard to any one decade.

The Twin Rocks and Copeland Creek Series IV constraint models were rerun to illustrate this point. This time, net sale value in the first time period was to be made as large as possible. The expectation was to obtain positive net sale values in each time period, but with a lower DNR. The tabulation below shows that it could not be done:

Time period	Twin Rocks		Copeland Creek	
	Original	Rerun	Original	Rerun
	Thousands of dollars			
NSV-1	−709	−709	−819	−626
NSV-2	—	—	617	652
NSV-3	4,121	4,121	14,983	13,908
Overall DNR	392	392	3,467	3,372

The Twin Rocks solution did not change at all. As it turns out, the original initial attempt to maximize overall DNR was identical to maximizing net sale value in the first time period. If 14.0 million bd ft of lodgepole pine and spruce are to be harvested from the Twin Rocks area during the first time period, costs always exceed revenues, even if DNR is sacrificed. For the Copeland Creek area, the rerun resulted in first-decade NSV changing from −$819,000 to −$626,000, a gain of $193,000. The price paid for the NSV increase was a reduction in DNR from $3,467,000 to $3,372,000 and more than a million dollar revenue loss in the third time period.

In general, a solution that yields maximum overall DNR can have a variety of cash flow arrangements for individual time periods. A positive DNR does not imply positive cash flows in each time period. In fact, a negative cash flow at some point in time may be necessary if the highest overall DNR is to be secured (as in the example discussed). If all cutting units associated with either the Twin Rocks or Copeland Creek solutions were packaged as a single timber sale, each would constitute a large BCTS, but yet each would be consistent with long-term management efficiency.

The previous section discussed how increasingly restrictive management objectives and concerns affect discounted net revenue. Although all DNR's remained positive, they decreased with increasingly stringent restrictions. It was not until the decade-by-decade analysis just presented that the first below-cost sale (negative NSV) was encountered. We now return to management objectives and concerns, but focusing exclusively on the decade-by-decade Series IV solutions just discussed.

From time to time, the argument is made that some Forest Service timber sales are below cost because of costly restrictions generated by nontimber objectives and concerns. To better examine this argument, we removed some restrictions. Recall that the Series IV solution was constrained by limitations on harvesting adjacent cutting units and limitations pertaining to timber harvest. A "maximum-timber" approach was simulated by removing the adjacency constraints, but maintaining the harvest requirement. Adjacency constraints are imposed largely for wildlife purposes and visual quality. Presumably, a timber-dominated approach would reflect less concern for those aspects of forest management.

Removal of the adjacency constraint had a substantial influence on DNR for both study areas, as shown in the listing below:

Time period	Twin Rocks		Copeland Creek	
	Original	Max-timber	Original	Max-timber
	Thousands of dollars			
NSV-1	−709	432	−819	−589
NSV-2	—	—	617	170
NSV-3	4,121	5,220	14,983	23,148
DNR	392	1,606	3,467	5,477

DNR increased by better than half on Copeland Creek and by more than 400 percent on the Twin Rocks area. Removal of the adjacency constraint also had a noticeable effect on the cash flow situation within each time period. While the negative NSV for the first time period in the Copeland Creek area became only less negative, the NSV on the Twin Rocks area changed from negative to positive. It showed a net increase of about $1.1 million, changing from an overall below-cost to above-cost situation. This, however, represents a conservative estimate of the net revenue that would likely be realized under maximum-timber management. On slopes ranging

from 35 to 60 percent, the Forest Service usually opts for skyline logging, which has less environmental impact but is more expensive than the tractor logging a maximum-timber approach would likely use. Our models included only skyline options for such slopes and therefore overstate costs that would be incurred in a truly maximum-timber approach.

The dramatic change in cash flow can be explained by comparing the original management solution (shown earlier in fig. 4) with the "maximum-timber" solution shown in figure 6. Several rather subtle changes occurred. While not apparent, the maximum-timber solution harvested about 50 percent more timber. That is, it always made financial sense to harvest more timber. Without the adjacency constraint, the model was free to so do. Both solutions ended up constructing about 40 miles of road, but the timing was quite different. In the original solution about three-fourths of the roads were constructed during the first time period. The maximum-timber solution constructed three-fourths of the road miles during the third time period. The reason for the road construction reversals is the most obvious difference between figures 4 and 6: there are no adjacency constraints reflected in figure 6. Given a choice between harvesting adjacent units versus dispersed cutting units, adjacent units were chosen. Notice the relatively large areas of identically shaded cutting units in figure 6 compared to figure 4. When adjacent units are harvested, relatively fewer miles of road are required to access the required timber in the first time period.

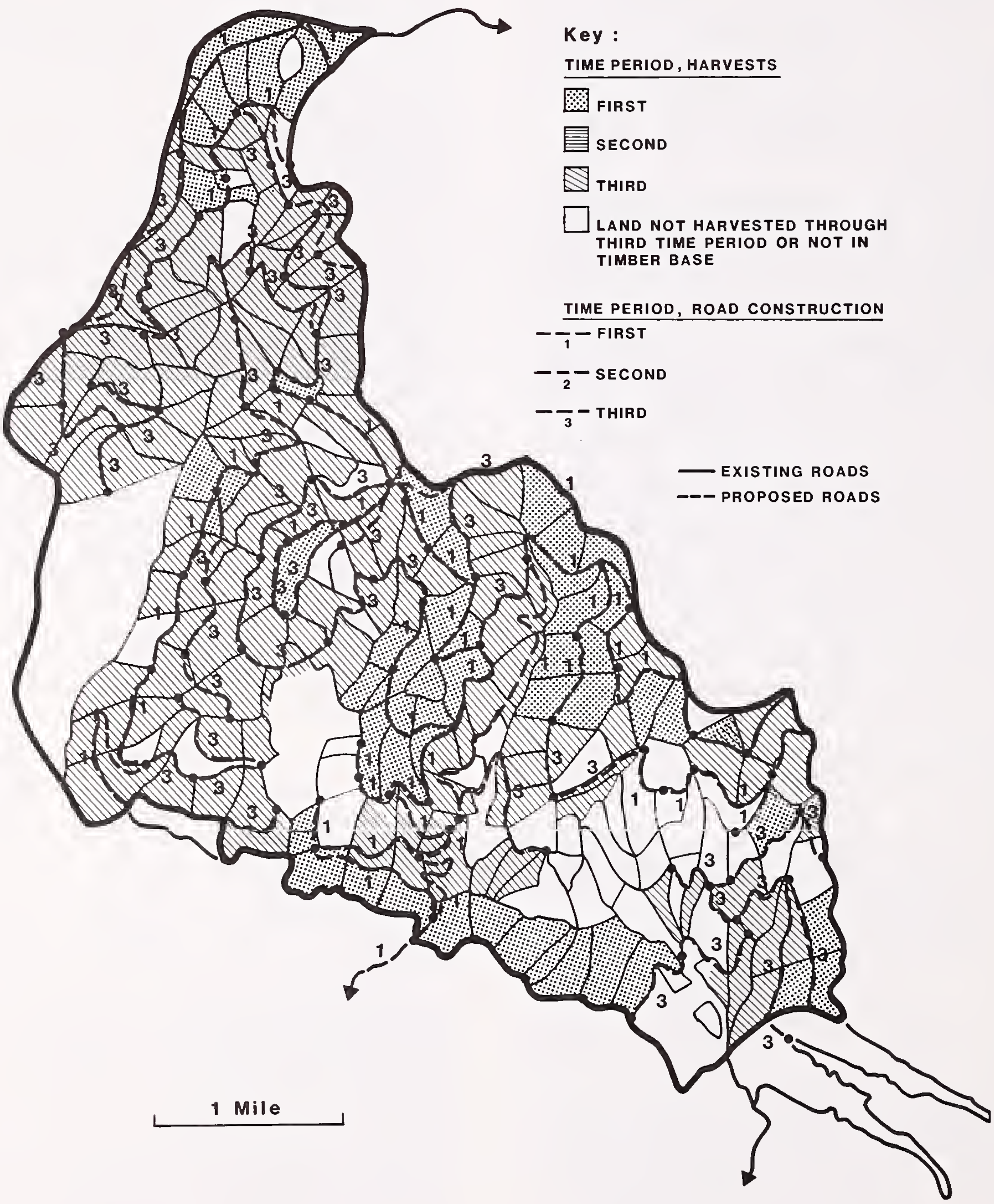


Figure 6.—Twin Rocks area solution: maximum DNR with lower limit timber harvest constraint; no adjacency constraint.

Sale by Sale.—Actually, the decade-by-decade view of the BCTS issue is broader than that suggested by either the GAO or CRS report. Those reports focus on specific individual sales. Previous decade-by-decade discussion can correspond to a sale-by-sale analysis only if all cutting units within a time period were packaged as a single sale. But sales can be packaged in many ways. In fact, as the size of the planning area increases, multiple sales would be more likely and perhaps even necessary. The multiple-sale approach would be equivalent to the phased development of a road network and associated cutting units within a time period. To illustrate how packaging decisions can affect BCTS, we will focus on examples that not only have positive DNR's, but where the overall NSV (undiscounted cash flow) is positive for each time period; there is no hint of a BCTS.

The listing below displays the NSV outcomes where a positive NSV during the first time period was administered as two sales rather than one:

	Twin Rocks	Copeland Creek
	------- *Thousands of dollars* -------	
Original NSV (TP1)	224	546
Sale 1, below cost	−269	−32
Sale 2, above cost	493	578
Total	224	546

The Twin Rocks example pertains to the Series III solution and the Copeland Creek example applies to the Series II solution. In both cases, a pair of timber sales were developed where one is "below cost," the other "above cost," and the two combined to a total equivalent to a single larger sale. In the case of Twin Rocks, one sale has a negative cash flow of $269,000, the other $493,000 positive; together they total to $224,000, which is the same as would have resulted from one larger sale. Packaging cutting units into two sales may not be a good idea for some other reason. But packaging choices cannot always be avoided, especially as the size of the area or the number of cutting units increases. The BCTS illustrated above represents packaging decisions, not financial losses.

EFFECT OF THE ANALYTICAL PERSPECTIVE ON BCTS CONCLUSIONS

Does the analytical perspective affect BCTS conclusions? Yes, it certainly does, and in a wide variety of ways. In fact, there are so many ways for analytical perspective to affect conclusions that the scope of this report must be restricted to three—roads as capital investments, multiple-use approach, and the 25 Percent Fund.

Roads as Capital Investments

The analyses presented in this paper have been based on the premise that the below-cost timber sale issue must be assessed in the managerial context of the Forest Service. Part of that context is that management decisions involve multiple time periods and multiple site considerations. This aspect of the managerial context at the same time clarifies an analytical question and renders it moot.

One of the more important questions that arise out of the BCTS issue is how to treat costs of constructing permanent roads. Some imply that the entire cost of roads constructed in conjunction with a sale should be charged against the value of the timber in that sale. Others argue that roads should be treated as a capital investment, and it is therefore inappropriate to charge all permanent road construction costs against a sale. This question is critical to analyses of individual timber sales. The Series IV solution developed for the Twin Rocks area provides a good example. The net sale value in time period 1 for this solution was −$709,000. Without the road costs, the NSV for that time period is positive, $411,000. The total road construction cost in time period 1 was $1.12 million. How road costs are treated could make the difference between a timber harvest appearing to lose money or to make money.

Capital investment theory supports the view that permanent roads should be treated as an investment. Any expenditure that secures an asset that provides a flow of services over time should be treated as a capital investment. In fact, that is one definition of capital. To the extent that roads constructed for timber harvest are either reused in the future to access the initial stand or become part of a transportation network, roads are a capital asset. Consider figure 4. There are numerous examples of roads that would be constructed to access timber in time period 1 that would be used to haul timber harvested in time period 3.

Capital investments are typically analyzed using discounted cash flow analysis procedures over a period of time, at least as long as the expected life of an asset. The analyses we have conducted in calculating DNR for the alternatives were designed to do just that, and generally do. Road costs enter these analyses, as do any other costs, on the basis of when they occur. These analyses, however, include the future benefits of the access provided by roads constructed in time period 1, a capital investment. Nevertheless, even this analysis is technically incomplete. Because only a 50-year planning horizon was adopted, potential road-related benefits occurring after year 50 are not included in DNR. Omitted are the benefits of access provided to existing stands which will be harvested after 50 years and to next-rotation stands on units harvested during the initial planning horizon. That management of these stands will be less expensive is not reflected in our analyses. This omission does not affect the calculation of DNR greatly, however, especially for next-rotation stands. The present value of future benefits occurring after 50 years is small, even at a 4 percent discount rate.

The difference between the discounted cash flow analysis, which has its focus on the long-term financial viability, and the practice of looking at the NSV of each sale individually can be striking. Consider again the Series IV solutions. The NSV's for time period 1 were −$709,000 and −$819,000, respectively, for Twin Rocks and Copeland Creek. Yet the DNR's for these solutions (which measure the net cash flow over the 50-year plan-

ning horizon) were positive for both areas, $392,000 for Twin Rocks and $3.467 million for Copeland Creek.

In our analyses road costs were treated in terms of a multiple time period and multiple site evaluations. In that sense, they were correctly treated as capital assets. But they were not treated so because we decided that they were capital assets. Rather, they were routinely handled as a cost in an overall analysis conditioned by the Forest Service's managerial context. Only if the analysis deviates from that context would a decision have to be made as to whether roads are capital assets. But the tendency of the BCTS controversy to focus on individual sales helps perpetuate the debate over the capital nature of roads.

Multiple-Use Benefits

Some have argued that critics use flawed analytical procedures when assessing below-cost sales. Critics count only marketable products and values and ignore products whose value is established outside traditional markets. The basic point of contention is whether a multiple-use analysis is appropriate. Thus far, this report may also appear to have adopted the more restrictive approach. The only multiple-use benefits counted in DNR calculations were timber revenues. This perspective was adopted only out of analytical necessity and to avoid ambiguity. The multiple-use approach is clearly correct.

The addition of nontimber benefits can, conceptually, transform a timber sale where costs exceed benefit values into one where benefit values exceed costs. Less clear is how such an analysis is to be accomplished. Analyses of relatively small areas, such as the study areas, frequently exclude the value of nontimber benefits. Why? In order to include these benefits, we must first estimate the amount of incremental nontimber outputs over time resulting from management. Second, we must assign economic values to those incremental outputs. These problems are easy to identify but difficult to solve. While it is difficult to establish a monetary value, estimating the incremental outputs, positive or negative, is more troublesome and central to analysis of BCTS.

There seem to be three classes of nontimber multiple-use benefits that have implications to BCTS analyses. First are those benefits on which the effects of management can be measured within the timber sale or a subforest area. Here we have in mind site productivity, water yield, or certain (nonmigratory) wildlife populations. Not only can the management effects be measured, they are also restricted to the local area, unaffected by what happens elsewhere on the Forest. The second class of multiple-use benefits may or may not be measurable, but their scope of consequence is larger than a sale or subforest area. Recreation, both developed and dispersed, along with mobile wildlife populations, are examples of this class of benefit. Limiting factors and site substitution are key considerations. Determining the management implications for this benefit class requires a multiarea or Forest-level geographical perspective because the overall consequences of management actions in one place depend on what happens in other places. The third class of nontimber multiple-use benefits involves those that, regardless of appropriate geographical restriction, are essentially nonmeasurable. Here we have in mind benefits such as gene-pools, ecosystem stability, and human life style.

A difficulty encountered when attempting to incorporate nontimber multiple-use benefits into BCTS analyses is that many, if not most, of those benefits fall into the second and third classes. Class 2 benefits are at the same time most appealing and most frustrating. This class includes many, if not all, of the nontimber benefits commonly associated with the concept of multiple-use, especially fish, wildlife, and outdoor recreation. Economic analyses that focus on a specific project, such as a timber sale, or even a larger area, such as a study area, are simply too limited in scope to capture the true incremental change in magnitude of these benefits. A broader geographical perspective, possibly Forest-level, is needed. The need for a broad analytical scope is not unique to nontimber benefits. The concepts of "sustention" or "nondeclining yield" for timber outputs also similarly require a broad geographic scope of analysis.

To say that the effect of management action cannot be measured at the site or area levels does not mean that incremental benefits are not generated. It means they cannot be measured at that level. They can be measured and are included in Forest-level analyses and land management planning efforts. At the Forest level, the analytical perspective is much more compatible with the overall scope of benefits and costs; comprehensive tradeoff analyses are possible. These analyses provide a basis for establishing overall management direction for a Forest and help specify management objectives and concerns, along with the types of prescriptions that will be used in local area management.

We were unable to quantify the incremental nontimber multiple-use benefits in the objective functions of the Twin Rocks and Copeland Creek models. For the class 1 multiple uses, the needed information and relationships simply do not exist and could not be developed in the time available. Measurement of the class 2 and 3 multiple-use benefits either requires a larger geographic scope, or they cannot be measured, as just discussed. Consequently, nontimber multiple-use values were not included in our DNR calculations. They were instead reflected in the types of activities (based on timber management projects, road projects, cutting unit delineations) from which the model can choose, and in the constraints imposed on the model. For example, the reason cutting units are restricted in size and that timber harvest is restricted to nonadjacent units is typically to enhance or protect wildlife populations and the recreation activities (hunting, wildlife observation, and so forth) associated with those populations. The decision that this is desirable management on a given class of land is made through the forest planning process. That Forest-level decision is then translated to a subforest area (study area, project, or sale) by specification of management prescriptions and other forms of management objectives and concerns applicable to the local area.

To the extent that production of multiple-use benefits is at least partially accomplished through timber sales, a complete accounting would compare the value of all of the costs incurred to the value of all the benefits generated. Many of the timber sale costs used in our analyses are "joint costs," costs incurred for an activity that produces two or more outputs simultaneously; neither output is possible without the other. Road costs may simultaneously produce timber and recreation access. Stump-to-truck costs may simultaneously produce timber and improve wildlife habitat. Yet, for reasons just discussed, the only benefits valued in DNR calculations are those associated with timber. In light of this, some recommend apportioning or allocating joint costs to the outputs produced. This, it is argued, would be a more correct portrayal of the true benefits and costs, a better way to assess the BCTS issue. Methods have been developed to apportion joint costs to outputs. They all share a common flaw: in terms of economic theory, none are unambiguously correct; in that sense, each method is arbitrary.

The danger in apportioning joint costs is that, if used to decide resource allocations, those costs can lead to incorrect choices. For example, it is possible for an alternative to have an overall positive incremental net benefit (incremental benefits minus incremental costs are positive) while, at the same time, joint costs apportioned to timber exceed timber revenues. Based on the net value of timber, this alternative would be rejected even though it has a positive net incremental benefit. The opposite situation is possible as well. It would be possible for an alternative to have a negative incremental net benefit, but the timber revenues exceed the costs apportioned to timber. In this instance, the net value of timber would lead one to choose an inefficient alternative. The problem with apportioning joint costs is that any result desired could be obtained simply by choosing the appropriate apportionment method; since any choice is arbitrary, one result cannot be judged better than another. One must conclude that the correct way to analyze efficiency when joint costs are present is to compare the sum of the incremental benefits to the incremental costs, including joint costs.

Because small-area management frequently involves joint costs, but analyses only include timber benefits, it could be concluded that all joint costs are being apportioned to timber, a purely arbitrary and undesirable procedure. This gives the appearance that joint costs were apportioned. In our analyses this, in effect, is what happened, but for a totally different reason. We simply could not estimate and value nontimber multiple-use benefits on the Twin Rocks and Copeland Creek areas. If we had that capability, there would be no need to apportion joint costs; since we could not measure nontimber benefits, we had no acceptable basis to apportion joint costs. The levels of DNR reported do not reflect the value of whatever nontimber multiple-use benefits exist, and we know of no satisfactory way of reflecting them at this level of analysis.

The 25 Percent Fund

One of the most controversial aspects of the BCTS issue is whether 25 Percent Fund payments to counties represent a cost against which timber revenues should be compared or are simply an income-redistribution vehicle, one part of an overall Federal program of sharing revenues with State and local governments. The perspective adopted can have substantial implications regarding BCTS.

The 25 Percent Fund, established in law back in 1908, calls for 25 percent of all monies received by the Forest Service to be paid to the States (and later distributed to counties) in which the National Forests are situated. The source of monies (timber, recreation, and so forth) is not important. The timber contribution has traditionally come from stumpage receipts. Then, in 1976, the concept of "monies received" was modified to include Knutson-Vandenburg (K-V) payments and purchaser road credits. Because payments to counties are apportioned on the basis of National Forest acreage therein, not revenue production, counties without any timber harvest will receive a proportionate share of 25 Percent Fund distributions. Also in 1976, the 25 Percent Fund became part of a bigger program of Federal revenue sharing as specified in the In-Lieu-Payments Act.

In order to estimate 25 Percent Fund payments from the study areas, Forest Service stumpage, K-V payments, and purchaser road credit had to be approximated. The only troublesome area involved K-V payments. This is because the timber harvest prescriptions used in IRPM modeling lumped regeneration and site improvement costs with some other activities not associated with K-V. Arbitrarily, K-V payments were approximated as 75 percent of these candidate costs. Throughout all DNR analyses, no distinction needed to be made as to whether road costs were funded directly by the Forest Service or indirectly by means of purchaser road credits. For purpose of 25 Percent Fund calculations, road costs were treated as if financed through purchaser road credits.

Considering the 25 Percent Fund payments as costs has a substantial effect on DNR. Levels of DNR for the Twin Rocks area decreased by more than 200 percent in the case of the Series IV solution as shown in the following tabulation:

Constraint series	Twin Rocks: Original	Twin Rocks: 25 Percent Fund	Copeland Creek: Original	Copeland Creek: 25 Percent Fund
	Thousands of dollars			
I	1,308	514	4,268	2,743
II	1,209	542	4,252	2,732
III	1,043	330	4,252	2,732
IV	392	−478	3,467	1,991

The other reductions for the Twin Rocks area ranged from more than 50 percent to almost 75 percent of the original DNR's. The reductions in DNR for the Copeland Creek area all slightly exceeded 33 percent. In the context of DNR per acre, the Series IV Twin Rocks area went from a positive $61 per acre to a negative $64 per acre.

The reductions in overall DNR due to 25 Percent Fund payments reflect only some of the implications. As shown earlier, a decrease in DNR increases the likelihood of a BCTS, and even a positive DNR can be associated with a negative NSV for a specific time period. In fact, treatment of 25 Percent Fund payments as a cost has substantial implication for NSV by decade. The tabulation below shows the net sale value in each time period for all solution series in the Twin Rocks area:

Constraint series	Time period	Twin Rocks: Original	Twin Rocks: 25 Percent Fund
		----- *Thousands of dollars* -----	
I	1	271	−65
	2	20	2
	3	4,491	2,482
II	1	379	76
	2	30	18
	3	3,703	2,080
III	1	224	−171
	2	32	20
	3	3,596	2,090
IV	1	−708	−1,276
	2	—	—
	3	4,121	2,529

In the original description of the NSV, time-period-by-time-period, only the first time period of the Series IV solution was negative. Recall that if all cutting units designated for harvest during that time period were packaged as a single sale, it would be one large BCTS. If 25 Percent Fund payments were considered a cost in the Twin Rocks area, all but one solution series contains a time period with a negative NSV. That is, a BCTS would be associated with most management approaches.

CONCLUSIONS

At the beginning of this report, we set out to address the hypothesis that BCTS and efficient management are not incompatible. We further stated that this question can only be addressed within the management context that the Forest Service must operate. This context includes regulations and the complex of administrative, statutory, and case law that clearly calls for systematic, integrative planning and management of National Forests for sustained, long-term production of multiple-use benefits so as to secure maximum net public benefits.

In view of this management context, our analyses do not support rejecting the above hypothesis. Four situations have been identified in which below-cost timber sales may not only be justified but essential for efficient management. Any attempt to eliminate a BCTS caused by these conditions will only serve to decrease overall net revenues (DNR)—management efficiency.

First, management of a large resource such as a National Forest must assume a broad systems perspective. As a result, each parcel of land in that system should be managed in the way that is perceived to be most efficient for achieving the management objectives identified for the system as a whole. This may not be the optimal way to manage a given parcel were it to be an entity of its own. In fact, a given parcel or management activity may itself lose money, but in the overall scheme be desirable and efficient. This "system" perspective is not unique to the Forest Service. For example, a forest products manufacturing firm may continue to operate a sawmill, even though it, as a profit center, is losing money. The reason may be that the sawmill is producing chips for the company's paper mill. The company as a whole is better off operating the sawmill at a loss than securing another, higher cost source of chips.

Second, some timber sales and their related activities are designed to provide incremental nontimber multiple-use benefits as well as timber benefits. The most efficient approach for accomplishing joint timber and nontimber objectives on an area may be to design projects wherein, while timber revenues do not exceed all the costs, the sum of the incremental timber and nontimber benefits does exceed the costs. This fits the multiproduct perspective that characterizes National Forest management.

Third, construction of permanent roads can cause timber sale costs to exceed revenues. Capital theory would suggest that costs incurred for construction of permanent roads be handled as a capital investment, regardless of the method used to pay for those roads. Such roads have a useful life that is substantially longer than that of one sale. Such expenditures are properly analyzed using discounted cash flow analysis that compares the cost of the investment to the discounted benefits realized over the life of the asset created. Road costs must be evaluated from a multiple time period and multiple site perspective.

Fourth, some on-the-ground decisions and some analytical decisions can also create the impression of a below-cost sale. Decisions about how to package cutting units to be harvested into sales can result in a BCTS. This was illustrated by packaging the units selected for harvest during a decade into two sales on each area. One sale had a positive NSV, the other a negative, thereby giving the **impression** of a financial loss.

In view of these four situations, we conclude that the presence of a BCTS proves little more than it exists. A sale might be below cost for one of the four reasons just discussed, as a result of inefficient or ineffective management, or various combinations of these reasons. The problem is, as we see it, the individual sale provides too short and narrow a perspective to conclude very much of anything about management efficiency. Management efficiency can be measured only by an analysis that takes a much broader and longer term perspective.

The below-cost timber sale issue is clearly important to the Forest Service. Resolution of the issue can affect the agency and its management programs and policies for years to come. It is therefore important to understand the concept of BCTS for what it is and is not. This report has carefully avoided dismissing the BCTS issue as ill-conceived, unfounded, or irrelevant. For indeed, there may be BCTS problems that need to be addressed and the data used to support conclusions in

the CRS and GAO reports may be correctly portraying a major management problem. But, based on our evaluations, it would seem that the only defensible conclusion that follows the mere identification of a BCTS is that such sales exist. This report has identified situations where BCTS's are not necessarily bad and may be an essential aspect of efficient management of the National Forest System. If so, the central issue may not be how to eliminate BCTS, but rather how to ensure that all BCTS's are only of the essential type and how to organizationally cope with them, given realities of budgetary processes and problems of public perception. Misunderstandings of the BCTS issue in today's managerial context can easily lead to inappropriate, misdirected responses which can deflect attention from effectively dealing with BCTS's and further confound the already complicated task of managing the National Forest System.

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Explores the question should the Forest Service sell timber for less than the costs associated with the sale? Issue is analyzed within the existing context of comprehensive land management planning. Several approaches to managing two study areas in Montana were developed. Below-cost sales were found compatible with overall management efficiency.

KEYWORDS: below-cost timber sales, land management planning, multiple-use, timber management, optimization

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